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(54) **Fibre optic tap**

(57) To provide a tap to an optic fibre light conductor, a graded-index rod a half-wavelength (or an odd number of half-wavelengths) long is used with an angled mirror surface half-way along its length. Two fibres meet opposite ends of the rod, and the output due to the mirror, which is of the partially-reflective type, provides the tapped output.

The reflected output thus produced is aimed at a photo-diode or, via a lens, at another optical fibre.

This gives a simple and economical tap, suitable especially for use in data transmission systems.

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Fig. 1.

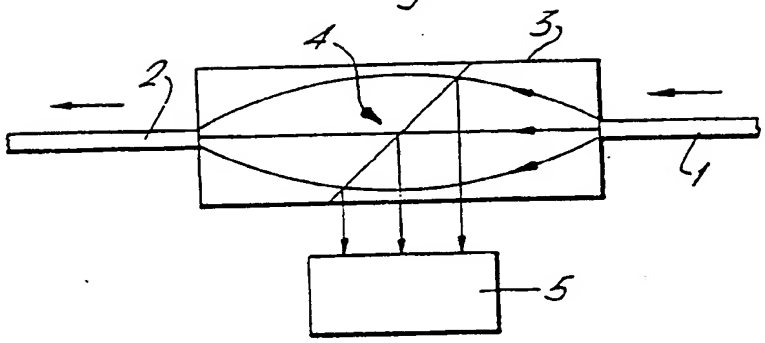


Fig. 2.

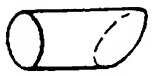


Fig. 3

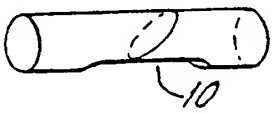


Fig. 4.

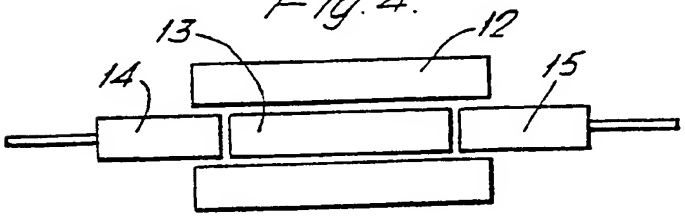
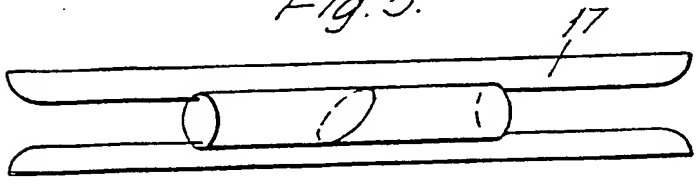


Fig. 5.



SPECIFICATION

Improvements in or relating to fibre optic devices

This invention relates to a tapping arrangement for an optical fibre cable.

In an optical fibre communications system it is frequently required to be able to tap off part of the light in transit along the fibre. One circumstance in which this is needed is in a closed-loop communications system where tapping off is needed at each of the stations on the system. Hitherto tapping arrangements for these and other purposes have been complex and/or loss-inducing and this invention has as its object the provision of such arrangements in which the above-mentioned disadvantages are minimised.

According to the present invention there is provided an optical fibre tapping arrangement, which includes a graded index rod whose length is an integral number of half-wavelengths long to one end of which may be coupled an input optical fibre or a light source and to the other end of which there may be coupled an output optical fibre, a partially-reflecting mirror set substantially at 45° to the axis of the rod, said mirror being an odd number of quarter-wavelengths from the input fibre or light source, and an output from the side of the arrangement, light reflected by said mirror leaving the arrangement via said side output.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which

Figure 1 is a schematic diagram of a first embodiment of the invention.

Figure 2 illustrates one stage in the manufacture of a device such as shown in Figure 1.

Figure 3 shows a useful improvement to the device of Figure 1.

Figure 4 and *5* show schematically further embodiments of the invention.

In the arrangement of Figure 1, an input fibre 1, or a light source such as a light-emitting diode or a laser, is coupled to an output fibre 2 via a graded index rod 3 whose length is half the waveplength of the light being propagated from the fibre or source 1 to the fibre 2. Midway along the rod 3 there is a partially-reflecting mirror 4 set, as shown, at 45° to the axis of the rod.

Light reaching the rod 3 from the fibre 1 or source is focussed for onward transmission via the fibre 2 by the rod 3, which acts as a lens. Partial reflection in the region of the collimated, expanded, beam by the mirror 4 directs a controlled portion of the beam onto a receiver indicated at 5. The control of the portion of the light which is thus reflected is by the extent and nature of the reflecting surface which forms the mirror.

The receiver is either a large-area photo-diode, or a lens focussing the diverted light onto a small-area photo-diode or an output fibre. The large-area photo-diode is the preferred form of receiver as this makes the arrangement relatively simple.

The device can be constructed from graded index fibre rod, e.g. 1 mm diameter so-called giant fibre drawn from a chemical vapour deposited preform, which is ground to the shape shown in Figure 2. That is, two rod sections are made each with one end normal to the axis and the other end at 45° thereto. The sloping end faces are then provided with suitable part-reflective optical coatings, and assembled together to form a cylinder such as shown in Figure 1.

To improve the optical coupling from the mirror to the receiver, a flat may be ground on the side of the graded-index lens assembly, as shown at 10, Figure 3.

Alignment of a graded index rod such as described above with respect to a precision bore tube or other alignment guide allows standard jewelled optical fibre terminating ferrules to be coupled to the device. Thus Figure 4 shows a precision tube 12, within which there are a graded index rod 13 and two ferrules 14 and 15 each of which terminates an optical fibre.

Another arrangement is shown in Figure 5, where we see centring using a tube 17 collapsed by the action of heat onto a graded index rod. This allows precise "spliced-in" connection to the fibres, relying for centring on the symmetry of the collapsing process.

Arrangements such as described above have a number of advantages:

(a) Simplicity, especially when used with large area, e.g. 1 mm square, photodiodes. The device is relatively cheap to make and is especially simple to install for those applications where the light to be tapped off can go straight to a detector.

(b) They are more efficient in principle than waveguide Y-junctions or the like, when the detector's area can be relatively large without significant penalty, and also when the fibres are of unknown size, i.e. the device is not custom-designed for a particular fibre.

(c) Fairly low insertion loss is attainable, which is important for ring-type applications where a signal may suffer due to loss of many devices in series.

(d) It can couple uniformly from all modes, i.e. it need not be mode-sensitive.

A variant on the arrangements described herein would be for the mirror to reflect fully over part of its area and not over the rest: this would select ranges of output angles for onward transmission and others for detection.

In the arrangements described herein the graded index rod lens is in fact one half wavelength long, but its length can be multiples of this as long as the mirror is an integral number (including one) of quarter wavelengths from one end.

CLAIMS

1. An optical fibre tapping arrangement, which includes a graded index rod whose length is an integral number of half-wavelengths long to one end of which may be coupled an input optical fibre or a light source and to the other end of which there may be coupled an output optical fibre, a partially-reflecting mirror set substantially at 45° to the axis of the rod, said mirror being an odd number of

quarter-wavelengths from the input fibre or light source, and an output from the side of the arrangement, light reflected by said mirror leaving the arrangement via said side output.

2. An arrangement as claimed in claim 1, and in which said rod is formed from two separate portions each of which has one of its end faces at 45° to the axis of the rod, the two end faces being placed one against each other to produce a cylinder.

3. An arrangement as claimed in claim 1 or 2, and in which the rod has a flat machined on its surface at the area via which light reflected by said mirror leaves the rod.

4. An arrangement as claimed in claim 1, 2 or 3, and in which the rod is centrally located in a precision-bore tube whose length is such that it can receive a ferrule-ended fibre in each of its ends, said tube being of transparent material.

5. An arrangement as claimed in claim 1, 2 and 3, and in which the rod is centrally located in a tube of a transparent material which is collapsed onto the rod.

6. An arrangement as claimed in claim 1, 2, 3, 4 or 5, and in which the light reflected by said mirror is directed on to a photo-diode.

7. An arrangement as claimed in claim 1, 2, 3, 4 or 5, and in which the light reflected by said mirror is directed by a lens onto an optical fibre.

8. An optical fibre tapping arrangement, substantially as described with reference to Figure 1, 2, 3, 4 or 5 of the accompanying drawings.

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